

Power-Sector Analysis for Regulatory Compliance

Multipollutant Modeling for Cap and Trade Systems

NREL Energy Analysis Forum

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Outline

- Background on IPM
- The Clear Skies Initiative: the basics
 - policy framework
 - costs and emissions reductions
- Renewables Modeling
 - cost and performance assumptions
 - renewables in IPM's projected energy mix

Background on IPM

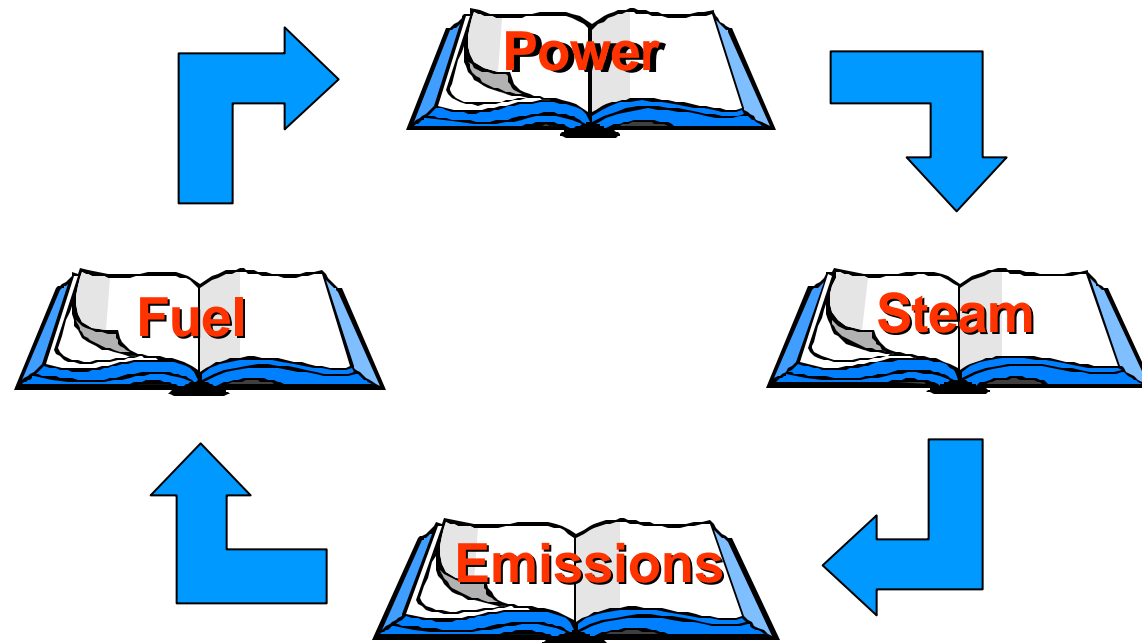
Background: What is IPM?

- The Integrated Planning Model (IPM) is a tool developed by ICF Consulting and used by EPA for policy analysis.
- IPM is a long-term capacity expansion and production costing model for analyzing the electric power and industrial, commercial, and institutional boiler sectors.
- **It is a multi-regional, deterministic, dynamic linear programming model.**
- IPM finds the least-cost solution to meeting electricity demand subject to environmental, transmission, fuel, reserve margin, and other system operating constraints.

Linear Program Advantages

- Finds optimal solution
- Comprehensive, integrated approach
- Bottom-up detail
 - Allows fine grain parameter variations
 - Analysis based on detailed disaggregate information

IPM Allows An Integrated Approach to Policy Analysis



Capabilities

- Captures complex interactions among power, fuel, and environmental markets.
- Environmental and generation planning with accurate system dispatch.
- Multiple regions with complex transmission interconnections.
- Endogenous pricing of coal, natural gas and biomass fuels.
- Comprehensive modeling of contracts, imports and exports.

IPM's Internal Structure

- Minimize the Present Value of Total System Cost subject to:
 - Electricity Demand Constraints
 - Reserve Margin Constraints
 - Environmental Constraints
 - Transmission Constraints
 - Fuel Constraints
 - Other Operational Constraints
- Perfect foresight feature provides ability to evaluate intertemporal tradeoffs.

Environmental Capabilities

- All major environmental compliance strategies can be modeled:
 - Retrofitting units with pollution control technologies
 - Fuel switching
 - Co-firing
 - Trading and banking
- Unit level emissions for air quality analyses

The Clear Skies Initiative

The Clear Skies Initiative Will Result in Aggressive Environmental Requirements for the Electric Power Sector

2004: The NO_x SIP call (summertime NO_x cap in 20 Eastern States)

2004

2008: Clear Skies NO_x Phase I (2.1 million ton annual cap is assigned to two Zones, with trading programs)

2008

2010: Clear Skies Hg Phase I (26 ton annual cap with national trading program)

2010: SO₂ Phase I (4.5 million ton annual cap with national trading program)

2012

2018: Clear Skies NO_x Phase II (1.7 million ton annual cap is assigned to two Zones with trading programs)

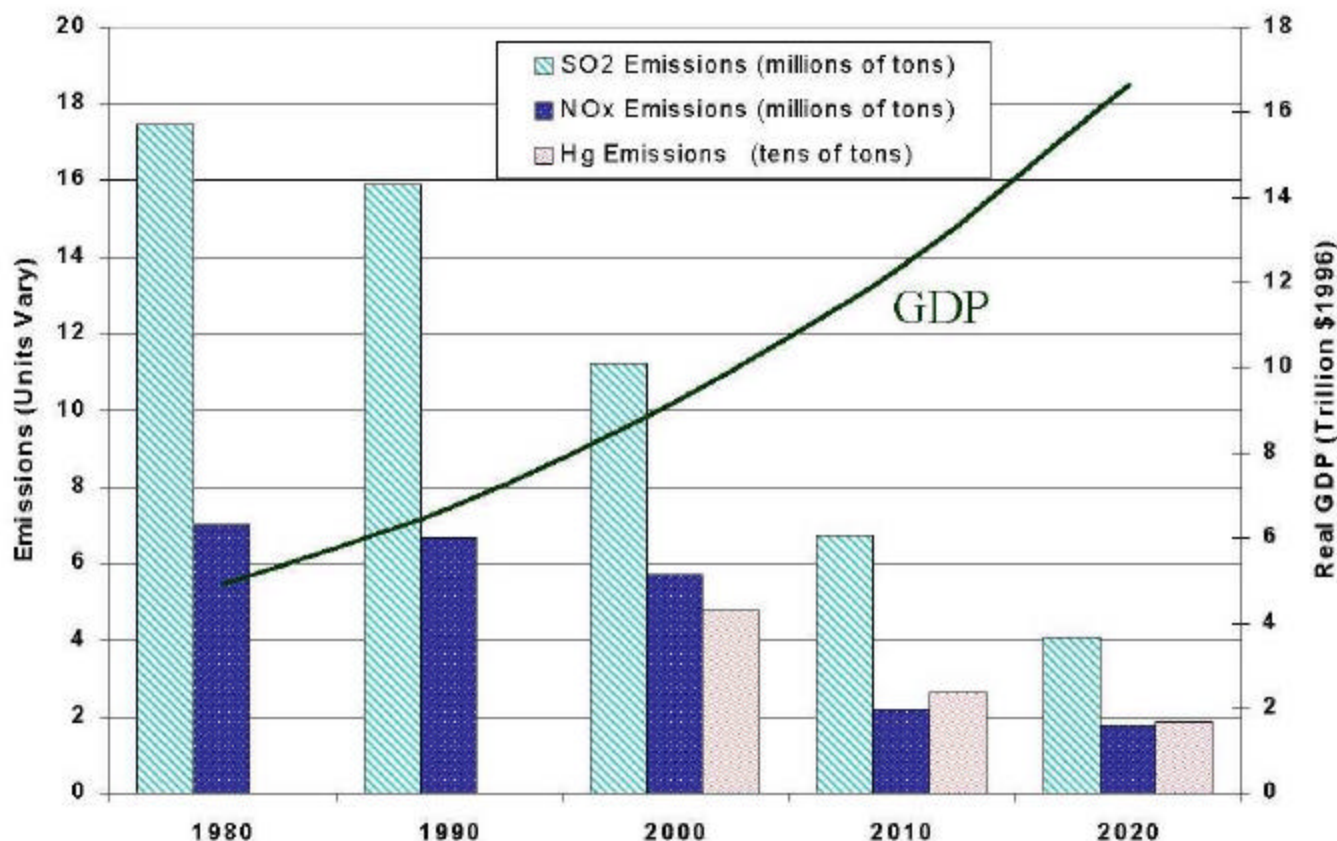
2016

2018: Clear Skies Hg Phase II (15 ton annual cap with national trading program)

2018: Clear Skies SO₂ Phase II (3.0 million ton annual cap with national trading program)

2020

Simultaneous Economic Growth and Environmental Improvement



Sources: 1970 - 1999 emissions data is from the National Air Pollutant Emissions Trend Report, (EPA, March 2000). Projections for SO2 and NOx are derived from the Integrated Planning Model (IPM). GDP data through 2000 is from the Bureau of Economic Analysis, GDP projections follow EIA's assumptions in AEO 2001 of 3% growth per year.

* Note: Emissions data include emissions from all fossil fuel-fired electricity generating units. 2020 emissions are based on the Phase II caps in the Clear Skies Initiative: a 3 million ton cap in 2018 for SO2, a 1.7 million ton cap in 2018 for NOx, and a 15 ton cap in 2018 for Hg.

Projected Annual Costs of the Clear Skies Initiative

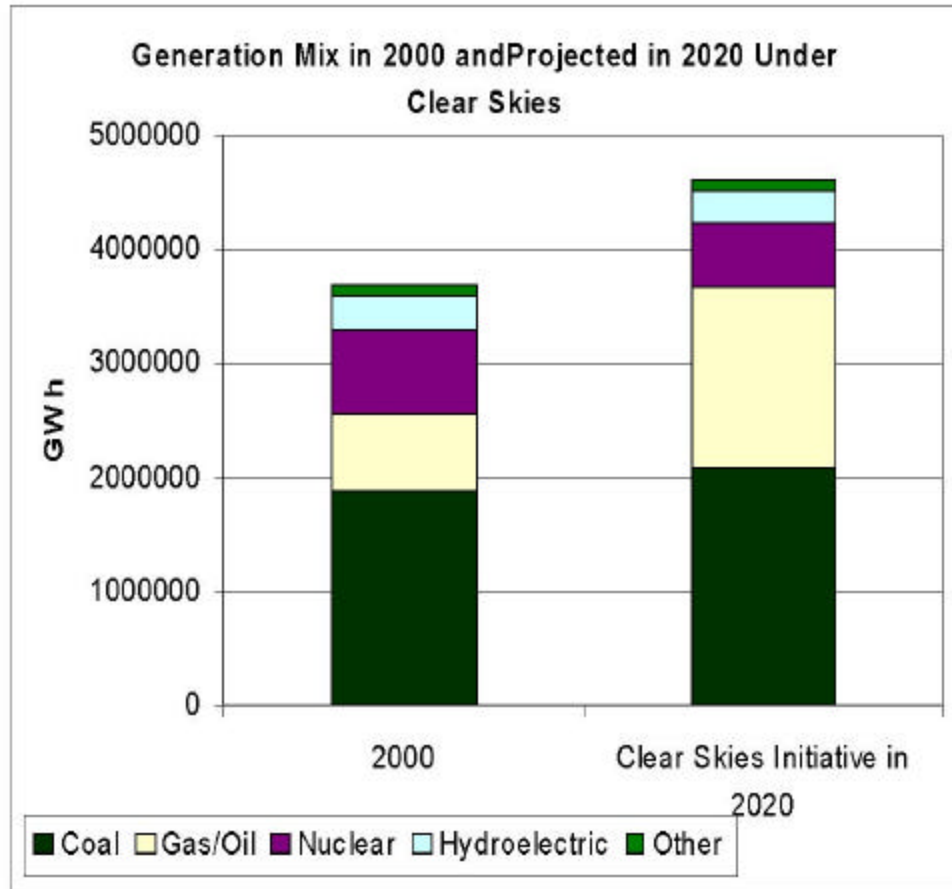


Notes:

- Cost projections assume the Phase II caps.
- Cost projections are EPA's estimates; EIA's modeling would likely show different costs.

NOTE: These projections show the costs to power generators over and above the costs they have already incurred to meet statutory and regulatory requirements that are already in effect. In the absence of Clear Skies legislation, there are existing statutory provisions that will, in the future, require EPA and states to impose additional requirements (and thus additional costs) on power generators between now and 2020. Because Clear Skies would use a highly-efficient cap-and-trade approach, it may be less costly in the future than continued implementation of existing law, even though it could achieve greater emissions reductions.

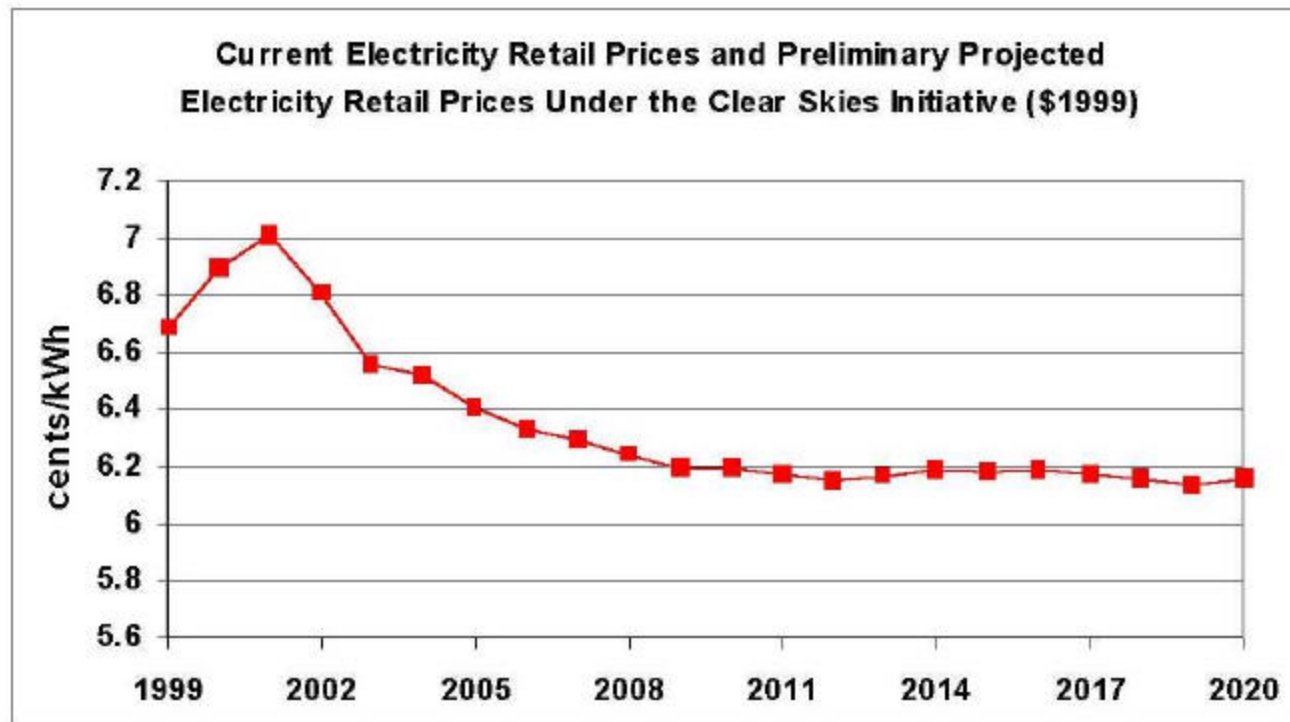
Electricity Generation Under the Clear Skies Initiative



Notes: 2020 generation projections assume the Phase II caps are in place. 2020 projections are EPA estimates. EIA's modeling would likely show different impacts.

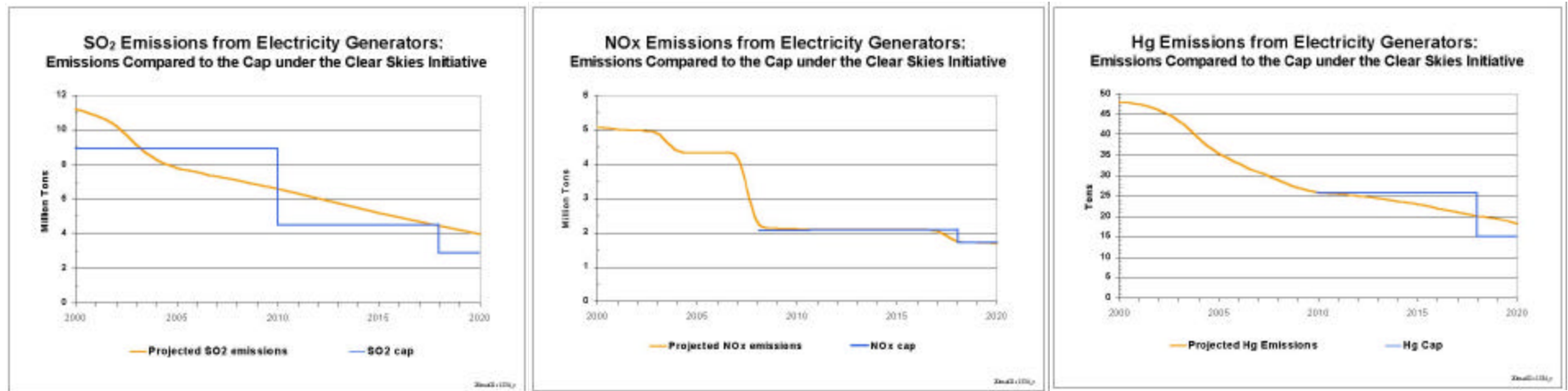
- **Fuel diversity is maintained under the Clear Skies Initiative**
 - In 2020 under Clear Skies, 45% of all electricity generation will come from coal.
- **Without legislation, generation from coal would likely be a smaller portion of the total fuel mix in 2020.**
 - To plan their compliance, coal-fired sources need:
 - Adequate lead time, and
 - regulatory certainty

Electricity Prices for Residential, Commercial, and Industrial Customers



- Although reducing pollution will require expenditures by power companies, in 2020, net electricity prices are expected to be lower under only the Clear Skies Initiative than recent (2000) prices. The efficient structure of a cap-and-trade program helps to keep the prices low.

Clear Skies Initiative for Electric Generating Units



- The Clear Skies Initiative will result in significant over-compliance in the early years because sources are allowed to bank excess emissions reductions and use them later. The use of these banked allowances for compliance in the later years of the program (e.g., 2020) results in SO₂ and mercury emissions above the cap in later years.

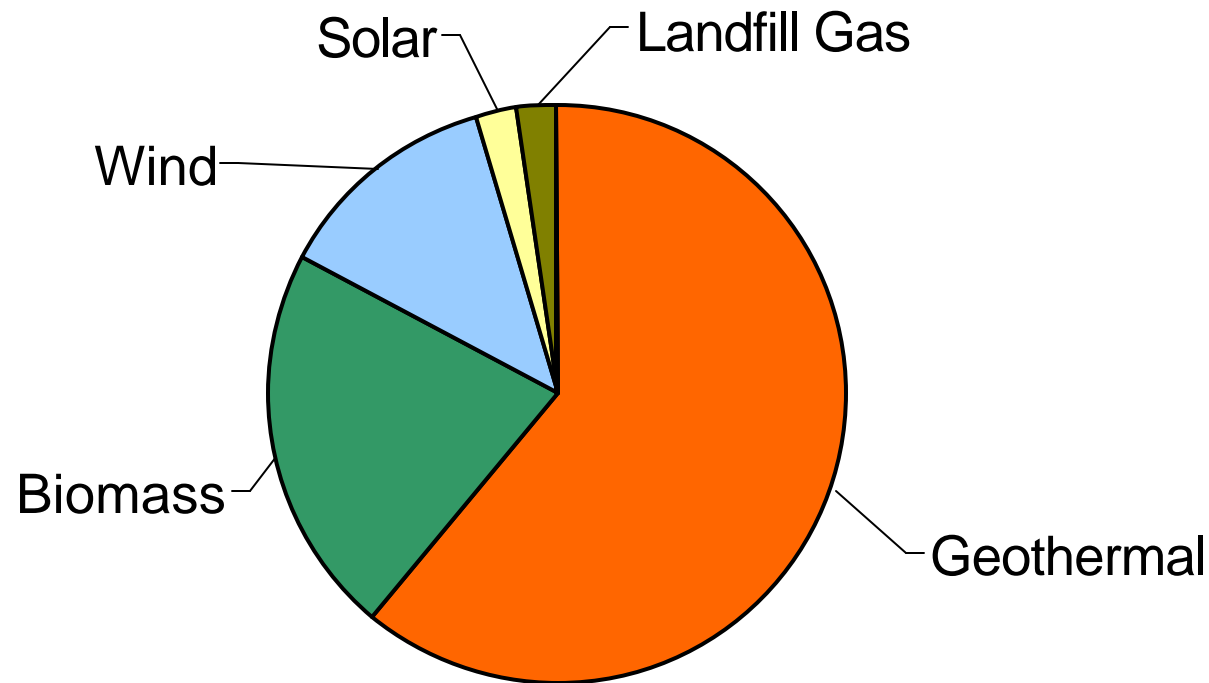
Renewables Modeling

Renewables in the Projected Energy Mix

- EPA Base Case 2000
 - renewables maintain roughly 1% of generation mix over 2005 - 2020
- EPA's modeling of Clear Skies Initiative
 - the market penetration of renewables does not change from the Base Case

Renewables in the Projected Energy Mix

Total Renewable Generation: ~ 34,000 GWh



Renewables Assumptions in IPM

Technology Characterizations

- based on EIA's AEO 2001

	Biomass Gasification Combined Cycle	Wind	Fuel Cells	Solar Photovoltaic	Solar Thermal	Geothermal	Landfill Gas
Size (MW)	100	50	10	5	100	100	100
First Year Available	2010	2005	2005	2005	2005	2005	2005
Lead Time (years)	4	3	2	2	3	4	1
Vintage #1 (years covered)	2010-2030	2005-2030	2005-2014	2005-2030	2005-2030	2005-2030	2005-2030
Heat Rate (Btu/kWh)	8,219	0	5,574	0	0	32,391	10,000
Capital (\$/kW)	1,490	1,031-2,625	2,175	2,576	3,187	1,848-6,174	1,299
Fixed O&M (\$/MWh)	44.81	26.41	15.00	9.97	47.40	62.40-210.50 ³	78.58
Variable O&M (\$/MWh)	5.34	0.00	2.06	0.00	0.00	0.00	10.48

Note: vintage #2 not shown (fuel cells only)

Possible explanation for low market penetration

- Impact of electricity demand assumption
- Low natural gas prices in model
- Absence of “market share algorithm” as used in NEMS

The Role of Renewables

- Are these results plausible?
- Development of an “Alternative Base Case”
 - more advanced renewable technology characterizations
 - inclusion of RPS